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INTERPRETATION OF SATELLITE-MEASURED BIDIRECTIONAL REFLECTANCE FROM CIRRUS CLOUDY ATMOSPHERES

Y. Takano, K.N. Liou, and P. Minnis
University of Utah
Salt Lake City, Utah 84112

Abstract

The present paper is concerned with the interpretation of the observed bidirectional reflectance from cirrus cloudy atmospheres. We have developed a theoretical model for the computation of the transfer of solar radiation in an anisotropic medium with particular applications to oriented ice crystals in cirrus clouds. In this model, the adding principle for radiative transfer has been used with modifications to account for the anisotropy of scattering particles and the associated scattering phase matrix. We have used the single-scattering properties, including the phase function, single-scattering albedo, and extinction cross-section, for randomly and horizontally oriented hexagonal ice crystals in radiative transfer computations.

Figure 1 shows the reflected and transmitted (diffuse) intensities for randomly oriented ice columns with a length/diameter ratio of 125/50 μm and area-equivalent ice spheres as a function of the zenith angle θ for an overhead sun. Significant differences between the reflected intensities for ice columns and spheres are evident. Ice spheres produce a peak intensity at $\theta = 45^o$, associated with a combination of primary and secondary rainbow features due to single-scattering. However, ice columns have larger reflected intensities in other zenith angle regions. In the transmitted intensity pattern, the 22^o and 46^o halo features produced by ice columns are very distinct for small optical depths, but they disappear when the optical depth is greater than about 16.

We have modified the radiative transfer model devleoped for cirrus clouds to account for the scattering contributions from the atmosphere and the surface. In order to test the relevance and significance of the ice crystal model for the interpretation of observed bidirectional reflectance from satellites, we have selected visible (0.55 - 0.75 μm) radiances collected on the half hour by the GOES series. The data will be calibrated and corrected with the proper filter functions, then navigated to match selected landmark data. A

number of clear and cloudy cases during the cirrus IFO of the FIRE experiment have been chosen for theoretical analyses. The cloud particle shape and size distributions that were taken during satellite overpasses are used in radiative transfer calculations. The sensitivities of the shape, orientation, and size distribution of ice crystals on the reflected intensities at the top of the atmosphere are investigated. Finally, the relative importance of these cloud microphysical properties in the interpretation of satellite bidirectional reflectance are assessed and presented.

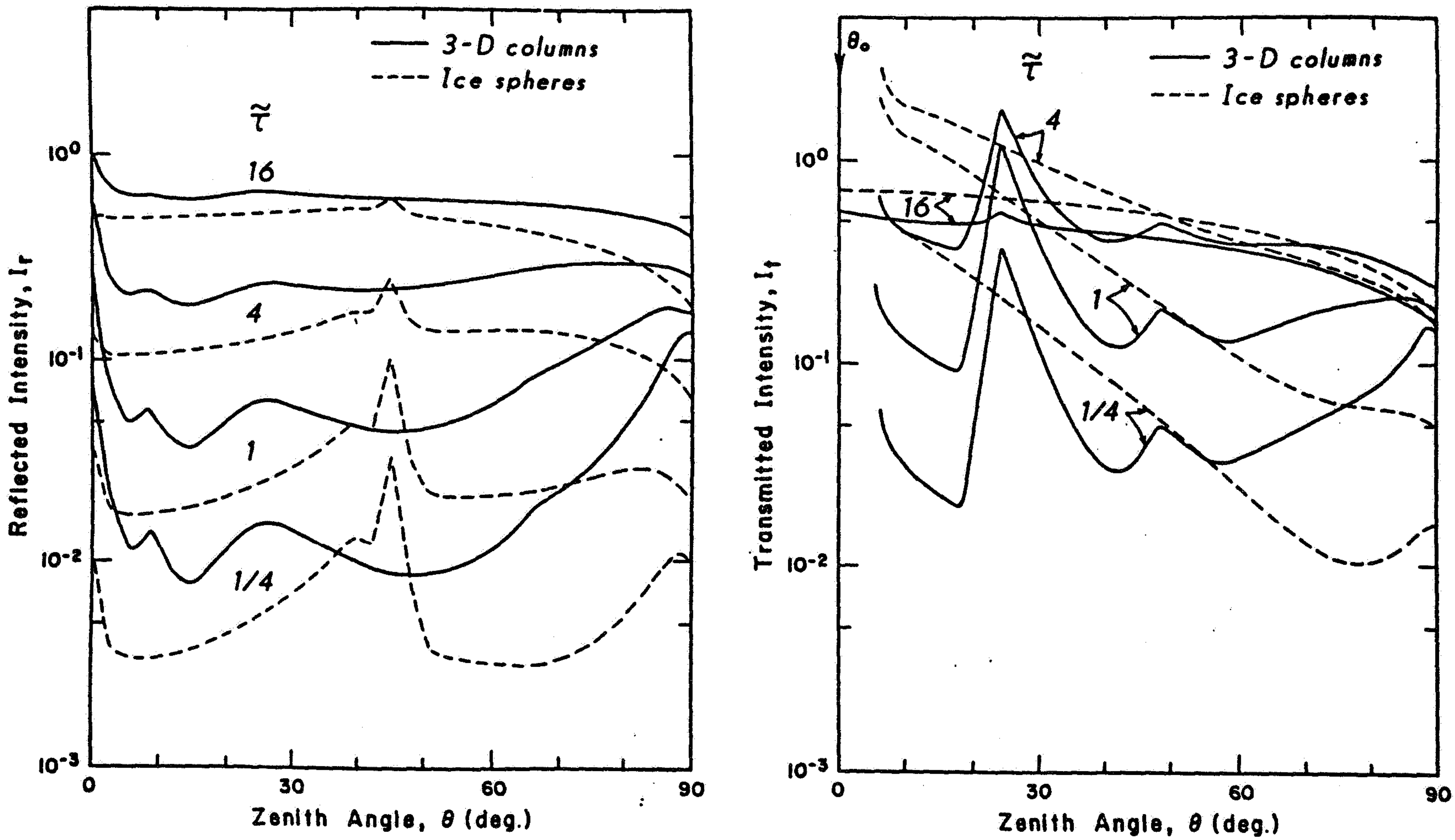

Fig. 1. Intensity reflected and transmitted by randomly oriented hexagonal ice crystals ($L/2a$ = 125 μm/50 μm) and area-equivalent spheres with an overhead sun ($\theta_o = 0^o$) at λ = 0.65 μm.